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STRATEGY RESEARCH PROJECT

SIMULATION AND MODELING FOR ACQUISITION, REQUIREMENTS AND TRAINING (SMART)

BY

LIEUTENANT COLONEL DAMIAN P. BIANCA United States Army

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USAWC STRATEGY RESEARCH PROJECT

Simulation and Modeling for Acquisition, Requirements and Training (SMART)

by

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The views expressed in this academic research paper are those of the author and do not necessarily reflect the official policy or position of the U.S. Government, the Department of Defense, or any of its agencies.

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ABSTRACT

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Modeling and Simulation (M&S) has long been used by Program Managers to support system development. Such M&S effort has normally constituted a small part of the overall program, been very specific in nature and not concerned with integration or collaboration with other acquisition activity. Shrinking Defense Budgets and increasing modernization-funding shortfalls, however, have recently prompted the Department of Defense (DoD) Acquisition policy to require M&S play an integral and much larger role in a program's acquisition strategy. The DoD name for this initiative is Simulation Based Acquisition (SBA) and is intended to reduce cost, cycle time and risk while increasing fidelity and utility of systems fielded to the Soldier. The Army has named its SBA initiative *Simulation and Modeling for Acquisition Requirements and Training*, or SMART. As its name implies, SMART goes beyond just the integration of modeling and simulation into a system's acquisition program. It seeks to accomplish the goals of SBA by leveraging information technology to support concurrent and continuous collaboration of the acquisition, requirements, and training communities early and throughout a system's life cycle. This collaborative process will play a vital role in supporting Army modernization and re-capitalization by enabling the Acquisition Community to deliver affordable systems in less time and with more utility.

Three salient questions to this relatively new process are: (1) What does a SMART program look like? (2) What are the benefits to be gained by SMART? (3) What is the Army doing to enable SMART, and what are its major challenges? The intent of this paper is to answer these questions in a manner that leads the reader to conclude that SBA is a SMART acquisition approach for the Army and that SMART does have a significant role to play in supporting Army modernization. The paper will focus on the Follow-On-To-TOW (FOTT) as a case study on implementing SMART in a program and the subsequent benefits of doing so. Comments about or recommendations for improving a particular process will be provided to illustrate or emphasize a particular point. A discussion on technology, infrastructure, culture and stewardship that enable SMART to be implemented faster and more efficiently will follow as a means to illustrate the Army's determination to make SMART integral to acquisition. Finally, major challenges that must be overcome for SMART to reach its full potential will be discussed.

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SIMULATION BASED ACQUISITION A SMART Approach for the Army

To pay for the modernization required to achieve the revolution in military affairs will require designing and building affordable systems and simultaneously cutting support and infrastructure costs. We must field and upgrade weapon systems on much faster cycle times in order to make the best use of continuing advances in technology, as well as trim costs. Techniques like modeling and simulation can help us in those areas by reducing risk, by saving time in development and production and by making efficient use of scarce and increasingly expensive resources.¹

- Jacques Gansler

Simulation Based Acquisition is SMART for the Army²

- LTG Paul J. Kern

Modeling and Simulation (M&S) has long been used by Program Managers to support system development. Such M&S effort has normally constituted a small part of the overall program, been very specific in nature and not concerned with integration or collaboration with other acquisition activity. Shrinking Defense Budgets and increasing modernization-funding shortfalls, however, have prompted the Department of Defense (DoD) Acquisition policy to require M&S play an integral and much larger role in a program's acquisition strategy. The DoD name for this initiative is Simulation Based Acquisition (SBA) and is intended to reduce cost, cycle time and risk while increasing fidelity and utility of systems fielded to the Soldier.³ The Army has named its SBA initiative *Simulation and Modeling for Acquisition Requirements and Training*, or SMART.⁴ As its name implies, SMART goes beyond just the integration of modeling and simulation into a system's acquisition program. It seeks to accomplish the goals of SBA by leveraging information technology to support concurrent and continuous collaboration of the acquisition, requirements and training communities early and throughout a system's life cycle. This collaborative process will play a vital role in supporting Army modernization and re-capitalization by enabling the Acquisition Community to deliver affordable systems in less time and with more utility.⁵

Three salient questions to this relatively new way of doing business are: (1) What does a SMART program look like? (2) What are the benefits to be gained by SMART? (3) What is the Army doing to enable SMART, and what are its major challenges? The intent of this paper is to answer these questions in a manner that leads the reader to conclude that SBA is not just a SMART acquisition approach for the Army, but, as Mr. Gansler's alludes to above, that SMART is a vital enabler to the Army's modernization effort. The paper will focus on the Follow-On-To-TOW (FOTT) as a case study on implementing SMART in a program, the subsequent benefits of doing so and, as necessary, recommendations for improving the particular process being discussed. A discussion on technology, infrastructure, culture and stewardship that enable SMART to be implemented faster and more efficiently will follow as a means to illustrate the Army's determination to make SMART integral to acquisition. Finally, major challenges that must be

overcome for SMART to reach its full potential will be discussed. A short primer on SBA and SMART is initially discussed to provide a context for the remainder of the paper.

SIMULATION BASED ACQUISITION - A PRIMER

The Army's SMART approach to acquisition is part of a broader Office of the Secretary of Defense SBA initiative. To understand SMART, one must first have an understanding of what SBA means. A typical SBA definition such as the one from the December 1998 Defense Systems Management College (DSMC) report defines SBA as "...an iterative, integrated product and process approach to acquisition, using modeling and simulation, that enables the warfighting, resource allocation and acquisition communities to provide affordable material solutions that meet the warfighter's needs." This and similar SBA definitions, however, may not do much for the uninitiated in M&S. An understanding of the definition of modeling and simulation is therefore necessary because, as the SBA definition above implies, there would be no SBA without M&S to enable the process.

The DoD M&S Master Plan defines modeling and simulation as the use of models, emulators prototypes, simulators, either statically or over time, to develop data as a basis for managerial or technical decisions. Models may be mathematical, physical, or virtual representations of the entity being developed. Simulations provide a method for implementing the model over time in real or synthetic environments for the purposes of testing, analysis, or training. Simulations can be broken down into three types: 1) virtual – an electronic or physical representation of systems; 2) constructive - such as a computer-run force-on-force war game and; 3) live – actual equipment being used in an exercise such as a simulated battle at the National Training Center. Any one or a combination of these can be used to provide information to decision makers.

Dr. Patricia Sanders, then DoD Director, Test, Systems Engineering and Evaluation, defined the SBA vision as "An acquisition process in which DoD and industry are enabled by robust, collaborative use of simulation technology that is integrated across acquisition phases and programs. SMART, as it was defined in the opening paragraph, simply substitutes the "acquisition, requirements and training domains throughout the lifecycle" in lieu of the phrase "across acquisition phases". In other words, SMART is directly inline with DoD's SBA vision.

Two notional vignettes are presented below to illustrate what has been discussed to this point. The first vignette demonstrates the typical product development without a SMART approach. The second vignette illustrates a program with a SMART.

Vianette 1:

Imagine an Integrated Product Team (IPT) comprised of the User, hardware, software design and producibility engineers, testers, maintainers, and financial management personnel, all building a prototype of System X piece by piece in a room. All of them are able to concurrently provide input on the design and performance of the prototype as it is being built. Budget and time allows for only one design. There is no ability to test the design to understand its performance under various conditions until it is completely built. The User's input is very limited because he has minimum knowledge of the true performance of the system until the whole prototype is built and tested in his

environment. The process in the end yields a physical prototype. The User does not particularly like the performance and wants to change some of the critical machine-soldier interfaces. Unfortunately, the engineers can't impact the performance or change the machine-soldier interface without significant redesign effort that will take a significant amount of time and resources. This process is repeated 3 times before the user is satisfied with the design. Because this iterative process has taken longer and cost more than planned, the training devices for the system have to be delayed until production of the system has started.

Vignette 2:

Imagine now the same scenario, except this time the IPT is concurrently working on a 3D virtual prototype of System X and that they have the ability to do so from various locations. An initial 3D prototype design is available from program start because the Request for Proposal stage required a 3D model for the Source Selection process. Each of the IPT participant's resident modeling and simulation infrastructure is capable of interfacing with the virtual 3D model. This enables the design to get iterated several times because of the near effortlessness it takes to try different approaches in the virtual medium vice working with hardware. When something doesn't fit, doesn't meet performance, is too costly, hard to manufacture or to difficult to support, the design is virtually reiterated until the issue is resolved. The User tries the prototype out in a synthetic environment from his resident Battlelab and knows before a hardware version of the prototype is built that it is what he wants. The virtual medium he has been using at this stage in the program is leveraged into an initial design for the system's training devices. Acquisition, requirements, and training have all been considered up-front and are applicable to the next phase of the program. In the end, less effort and time has been taken to get to an affordable design that meets the User's needs and the one prototype that is built has a much better chance of being right the first time!

The virtual infrastructure and information-based process in the second vignette enhanced the ability of the appropriate agencies to collaboratively work the prototype design in a virtual environment. The participants leveraged the virtual environment from various locations to induce and track design changes and to exchange information in near real-time. In the end, the SBA approach allowed the IPT to more rapidly obtain a better and cheaper prototype design without bending metal or tooling up for the effort until everyone had consensus on the optimal design.

While vignette 2 provides a simple application and concept of SMART, it does not provide a model for realistically implementing SMART in a program. The Follow-On-To-TOW program case study will be examined for that purpose.

FOLLOW-ON-TO-TOW (FOTT)- A SMART CASE STUDY

Although the FOTT program was not funded in the 98 mini-POM and was subsequently overtaken by the TOW Fire & Forget System, it was chosen for a SMART case study for three reasons. First, the author was most familiar with that program. Second, M&S was considered an integral aspect of the program throughout the system's life cycle in accordance with SMART principles and, and third, the program's Simulation Support Plan was - and still is - considered a model for others to implement. ¹⁰ Because FOTT was an ACAT-1D program, the Simulation Support Plan (SSP) required approval by the Army's M&S approving agency, the Test Integration Working Group (TIWG) and the DoD's M&S

approving agency. ¹¹ The program was structured to require a balanced comprise between simulation and hardware across the life cycle. A brief description of the program and the Simulation Support Plan will be discussed first, followed by the planned application of M&S across acquisition phases and the three domains – requirements, acquisition and training.

THE PROGRAM

The FOTT program was to have been the replacement to Tube-launched, Optically tracked, Wire-guided (TOW) missile. The approved Acquisition Strategy called for the development of a fire and forget missile that would be compatible with existing TOW missile launchers and training devices on the High Mobility Multipurpose Wheeled Vehicle (HMMWV) and the Bradley Fighting Vehicles (BFV). The new missile was to leverage "state-of-the-present" technology as a means to mitigate risk and enhance the program's ability to go directly into development. Appliqué kits would provide the interface between the new missile and platform. The complete system diagram is shown in Figure 1. ¹²

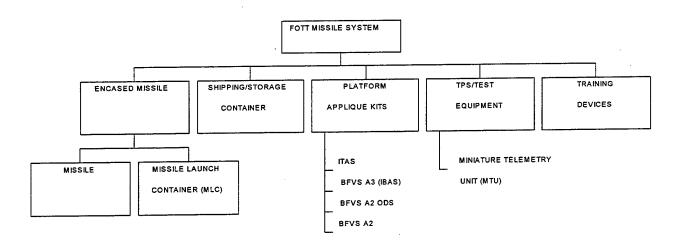


FIGURE 1. SYSTEM DIAGRAM

The Improved Target Acquisition System (ITAS) and the Improved Bradley Acquisition Subsystem (IBAS) – the newest models of the TOW system - employ 2nd Generation FLIR and digital technology for target acquisition and missile tracking capability. These newer platforms were designed to accept a new missile capability such as FOTT through a simple "plug-n-play" appliqué. The older HMMWV and Bradley Vehicle TOW-2 systems, which employ 1st Generation FLIR and analog target acquisition and missile tracking capability, required a more robust hardware & software appliqué design. Training devices for the respective platforms required a similar level of effort. Affordability, like performance, was a critical and

independent aspect of the program, i.e., the User could trade performance for cost given the budget constraints. To obtain a desired level of performance at an affordable cost, an SBA approach was fully integrated across the program's life cycle and the acquisition, requirements, and training domains. Hence, SMART formed the basis for executing the FOTT program.

The FOTT program Acquisition Strategy and the Simulation Support Plan (SSP) defined a SMART development, fielding and support process that leveraged M&S from program start. Figure 2 provides an outline of the M&S activities that were planned and budgeted for the FOTT program according to the FOTT SSP. ¹³ The SSP, required per the Assistant Secretary Of the Army, Program Assessment, was originally looked upon by the FOTT Product Team as just one more Milestone II document that added little value. However, that attitude changed over time and the SSP became a very useful tool for three reasons. First, it forced the PM to examine M&S requirements within and across all domains, particularly the test community. Second, the SSP provided a roadmap for when M&S tools needed to be coordinated, funded, and on-line to support specific events across the lifecycle of the program. This was particularly crucial for M&S tools required upfront in the program. Third, it kept the PM from investing in simulation for the sake of just doing simulation. All M&S was directly tied to an event or to a specific programmatic question that had to be answered to successfully complete development or production.

There is some on-going discussion to make the SSP a mandatory Milestone Review document. The author does not endorse that idea. The SSP should remain a supporting Milestone Document that is worked within a program's Integrated Product Team (IPT). A representative from the appropriate M&S Domains should serve on that IPT to insure the Army's M&S interests are best served. There is sufficient guidance in DoD Directive 5000.1 and DoD Regulation 5000.2R that directs the PM to use M&S as an integral part of the program's acquisition strategy. Regardless of whether the SSP becomes mandatory, the author would recommend that program managers develop the SSP as early as possible to gain visibility into of the M&S efforts required to support their program.

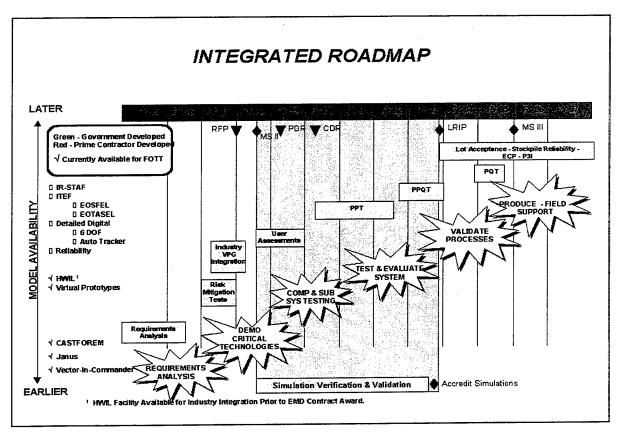


FIGURE 2. PLANNED M&S ACTIVITIES

REQUIREMENTS

The Program Executive Office for Tactical Missiles (PEO-TM), TRADOC System Manager-Antitank (TSM-AT) and the Close Combat Anti-Armor Weapon Systems (CCAWS) Project Office began to analytically work the requirements for FOTT approximately three years prior to the planned 1998 program. Initial analytical studies were conducted by the PEO-TM and then followed by the Army's Anti-Armor Requirements Review (A²R²) using constructive force-on-force models. Validity of the FOTT requirements and its contribution to the Infantry's close anti-tank battle were the primary focus of these initial efforts. The TRADOC Analysis Command at White Sands Missile Range (TRAC-WSMR) was commissioned to do both studies to provide an objective review of the requirements and to lend credibility to the study. The FOTT program also sought to leverage the initial PEO effort into the Analysis of Alternatives (AoA) study that TRAC-WSMR would be required to do in support of the program's Milestone II Review. This was accomplished through the fact that the initial PEO study, the Army's A²R² study, and the AoA used similar configurations of JANUS and CASTFOREM models. ¹⁴

As a result of the early analytical studies, increased range and fire & forget became FOTT critical performance parameters, or KPP's. These system attributes provided the level of survivability and lethality performance sought after by the User. Final validation of these KPPs by the Joint Requirements Council (JROC) was to be supported by the AoA six months prior to the Milestone Review. Unfortunately,

for a number of reasons, the AoA was not started early enough to properly support the JROC or the Milestone Review. One of the major reasons was that no one person in a position of sufficient rank seemed to be responsible or capable of getting the effort started. There was also a concern that the AoA had to be completed within 90 days of the Milestone to be relevant, regardless of the fact that the FOTT AoA was required much earlier to support the JROC. The Program Manager, the PEO, nor the TSM were capable of making it happen any faster. In the end, the JROC validated the KPPs based on the earlier PEO-TM and Army studies. However, the overall AoA process was not a well coordinated or executed effort. The result was very compressed and ill-completed AoA that was briefed to the Army and DoD within 45 days of the Milestone Review. There was no time to critically review and question the outcome of the analysis, or recover from obvious errors made in the modeling effort. In the end, while all other Milestone Review preparation was exceedingly done well by the IPT, this one issue significantly impacted the program.

Two issues that were pervasive throughout all constructive M&S activity done by TRAC-WSMR were the lack of configuration management of their models and the performance inputs of the systems being modeled. On the first issue, there wasn't a good system in place or the requisite funding to make it happen. If such a system had been funded, it could not have been implemented quickly enough to change the TRAC-WSMR culture nor positively impact the FOTT AoA. The second issue could have been remedied by TRAC-WSMR. They could have been more of a team player at the start and allowed key members of the development team the necessary visibility to insure system performance and operational attributes were properly incorporated into the models. Instead, they kept the development team at arms length until pressure was applied to change the situation. By then, too much time had expired to make any difference in the outcome.

There are three lessons to take from the Requirements effort. First, it is important to get the User involved early in the M&S effort to sort out system requirements. Second, it is beneficial to have TRAC-WSMR do any early studies of your system. The early studies get them involved with your program, lend credibility to the study results and provide connectivity to the eventual AoA that will be done to support the Milestone Review. However, get the AoA started as early as possible. It is time consuming, difficult to get started and even more difficult to get everyone to buy into the results. An abbreviated AoA can be done just prior to the Milestone if there is a concern for completing the AoA too early. While the requirements piece of the SMART approach was being executed, CCAWS was simultaneously planning the acquisition and training M&S required to support the program.

ACQUISITION

The use of M&S to support the FOTT acquisition program was predicated upon three key principles – leverage, early development, and connectivity. Because the program was not recognized as a formal acquisition program during the early planning stages of the Concept Development stage, there wasn't a lot of money to be used for M&S. However, it was critical to have the requisite M&S tools on line early to support the proposal and early Engineering and Manufacturing Development (EMD) design

efforts. The PM was able to mitigate this issue by leveraging significant M&S resources already resident in the Missile Research Development and Engineering Center (MRDEC) and the Redstone Technical Test Center (RTTC). Significant M&S data was also obtained from resident Project Offices at Redstone such as ATACMS-BAT, JAVELIN, NLOS and LOSAT. Leveraging the existing infrastructure was relatively simple given the breath of experience within the two organizations. The difficult part was searching externally for M&S data sources, because no single repository existed at that time. Therefore, significant time and effort was required to leverage M&S data into the program's SMART effort.

Prior to considering any acquisition-related M&S activity, the CCAWS Project Office developed a FOTT program plan and schedule that included all events from Pre-EMD through production, fielding, and support. All M&S activity was then cross-linked and tied to supporting specific events. This ensured that M&S wasn't being done for the sake of M&S and that program dollars were being wisely spent. After M&S requirements were established, an M&S IPT determined what M&S was already online, when a specific M&S tool was required, when infrastructure development needed to be started and the M&S funding requirements. The M&S IPT included major players from the Technical and Development test communities, which later enabled those communities to readily accept and support the SSP and the Test and Evaluation Master Plan (TEMP). A partnership, for instance, was developed with the Test and Evaluation Command (TECOM) to develop one of the centerpiece M&S efforts – the Virtual Proving Ground (VPG).

The VPG was a state-of-the-art testing tool that required a significant upfront investment from TECOM and the CCAWS Project Office. Approximately \$20M was invested by TECOM to develop the VPG and CCAWS committed to providing approximately \$15M over the course of FOTT's development and a significant amount thereafter to support production testing. The CCAWS PM's willingness to commit to using the newest state-of-the-art range and to invest in M&S was crucial in obtaining acceptance by the acquisition community for the Acquisition Strategy, the Test and Evaluation Plan (TEMP) and Training Device Strategy. The benefits of doing so will be discussed later.

Without getting into details of the VPG, Figure 3 and Table 1 provide a picture of what it was comprised of and the planned funding requirements, respectively. What's critically important is what the VPG provided - the first true end-to-end test of a missile in the virtual realm. It was capable of providing detailed, digital synthetic representation of the ranges, with various environmental conditions, under which the FOTT missile was to be tested. The test community was convinced that the VPG would allow them to adequately stress the missile under realistic, "simulated" flight conditions. The VPG could also allow gunner errors or sub-system issues to be found prior to actual rounds going down range. This benefited the program in two ways. First it gave greater confidence that a successful flight event and evaluation would occur and second, fewer spares were required to ensure a successful test program. The reduction in actual range time and missile hardware would have provided a significant return-on-investment for the VPG. Plans were made to digitize Redstone, Eglin Air Force Base ranges and the planned operational test ranges. Figure 3 shows that the VPG was capable of being linked to other M&S

tools used by the FOTT program such as the Virtual Prototype System (VPS). This connectivity would enable soldiers to train-up for technical and operational tests in advance using the Virtual Prototype System (VPS). Operational testers would have had the ability to answer many of their operational concerns prior to the actual operational test, saving significant time and money.

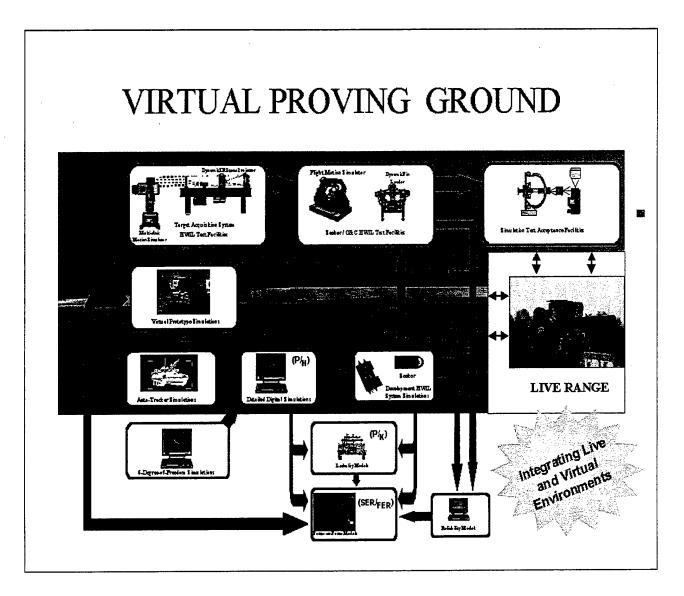


FIGURE 3. VIRTUAL PROVING GROUND 17

	FY97	FYES	FY99	FYOO	FYOI	FY02	FYOJ	TOTAL
MR55	Ō	150	1,000	1,100	1,000	850	825	4,925
EOSFEL	0	0	500	525	650	775	225	2,625
\$R	8 0	505	1,065	280	85	195	30	2,240
005	Đ.	Q	Q	300	400	310	400	1,410
VPS	205	230	200	200	150	150	200	1,335
ATS	Ō	160	231	235	Z3 0	175	121	1,162
6-DOF	0	100	300	Q	0	Q	Ç	400
FOF	0	30	30	30	30	30	30	180
LETHALITY	Q	5 0	75	35	35	50	75	7/0
TOTAL	285	1,225	3,351	2,705	2,580	2,535	1,305	14,537

TABLE 1. M&S PLANNED COSTS (FY 97\$)¹⁸

The Acquisition Strategy has already been discussed to some detail. However, enumeration upon a couple of critical points is necessary at this point. The first point is that M&S was fully integrated into the FOTT program so that there was a good balance between hardware and M&S activity to support the EMD program. If M&S were eliminated, significantly more hardware, time, and effort would have been required. For instance, the development program would have cost approximately \$200M more and production testing another \$100M without a SMART approach. The savings in production testing was estimated to be another \$80M. Put another way, CCAWS expected a return of about three dollars for every one dollar invested in M&S. These figures are conservative and don't take into account additional savings that would have accrued during product upgrades. The second point is the fact that the leadership at all levels, particularly from within key Army and OSD agencies, supported the FOTT M&S program. They accepted the new way of doing business and were willing to provide the upfront investment to make it happen at a time when the acquisition culture had not bought into M&S. As discussed earlier, this was specifically true in the Test Community.

The use of M&S tools to support testing and evaluation provided the largest savings to the program and formed the centerpiece of the FOTT SMART effort. The focus of M&S in this domain was to reduce the amount of hardware normally used in a missile test program while maintaining the confidence of the technical and operation test communities. Javelin, a similar missile program for instance, used approximately 120 missiles in their development test program (M&S was not technically mature enough to support the Javelin's development program. It is being effectively applied in the production phase). The FOTT program planned to use only 42 missiles during its development program. That number of missiles provided the minimum number of acceptable events for model validation and verification - accreditation was planned after EMD as part of the Production Qualification process. The test community then developed a design of experiments to ensure that the maximum amount of technical /operational information was gained from each missile flight. Figure 4 shows the estimated amount of savings the VPG and its related M&S technology were capable of providing by reducing the number of live missile flirings.

The VPG was a state-of-the-art capability in 1995. It took the TECOM, MRDEC and CCAWS leadership working together to make the VPG a reality. The CCAWS PMO was asked to commit to a significant investment to fund a capability that would eventually be used by other missile programs. It was crucial to make the upfront investment to have the VPG capability early in the FOTT program. Given the limited funding stream for the first two years of the program, the decision to fund M&S versus other program activity was not taken lightly and incurred significant risk. There was significant risk just in using a new capability such as the VPG. However, the potential payoff as seen in figure 3 offset the level of risk enough to prudently go that route. Early planning and funding of the infrastructure mitigated much of the VPG related risk. The VPG was to be brought on-line and tested in stages to give the PM time to execute alternatives.

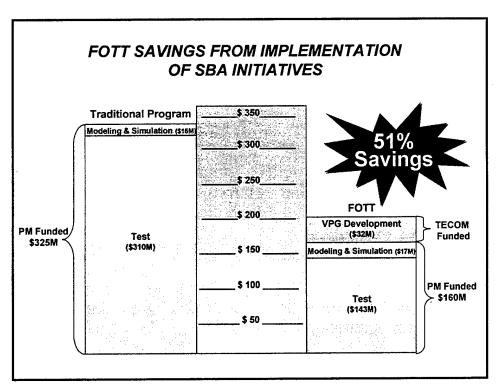


FIGURE 4. ESTIMATED EMD SAVINGS (FY97 \$) 19

Another important point to note is that the VPG and its related M&S did not benefit just the FOTT program. There was significant leverage between CCAWS programs across the lifecycle as shown in Figure 5. Javelin, Brilliant Anti-tank Munition (BAT) and Non-line Of Sight (NLOS) were also able to capitalize on the VPG and its related M&S tools. The TOW Fire & Forget and future Common Modular Missile systems are expected to significantly leverage the VPG. Finally, training devices of all these systems can leverage the scenes, targets, countermeasures, and scenarios developed for the VPG.

HTI THROUGH SIMULATION INFUSING *SMART* ACROSS THE ACQUISITION LIFE CYCLE AND PROGRAMS

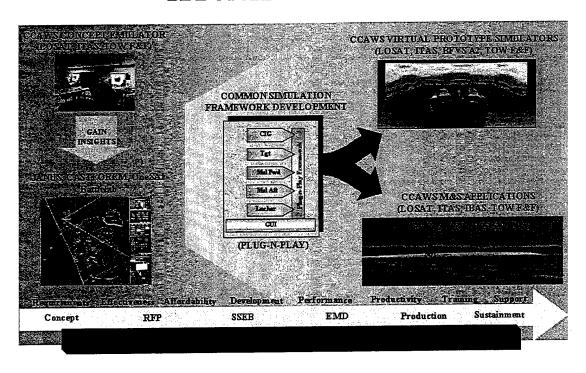


FIGURE 5 CCAWS SMART HTI²⁰

TRAINING

Training devices for the FOTT program were planned along two paths - embedded and appended. Embedded devices were planned for the newer, digitized platforms such as the Improved Target Acquisition System (ITAS) and the Improved Bradley Acquisition Sub-system (IBAS) on the Bradley-A3. Appended devices were a cost effective way to provide on-board training for the older analog TOW platforms. Both avenues looked to leverage the extensive VPG database and avoid the costly development and time associated with doing so as a standalone activity. The power of the personal computer and CD-ROM technology were to be harnessed to provide affordable training devices at the individual, section and platoon levels. Commercial, open-architecture hardware was to be used to the maximum extent possible to permit easy upgrades and to avoid proprietary, stove-piped training devices. With the exception of the Emulator, there were no other new training devices required to support the FOTT program. Existing platform training devices were to be upgraded and made FOTT compatible through software and/or hardware appliqué. The User and the Simulation Training and Instrumentation Command (STRICOM) were brought on board early to assist with the training device strategy and to ensure that the Request for Proposal was appropriately written to obtain the best suite of FOTT training

devices for the Soldier. More importantly, the training devices were to be developed in parallel with the M&S effort so that at they would be on-line to support FOTT fielding.

To this point, we have shown how to implement a SMART program through the FOTT case study. The FOTT program was on the leading edge of SBA at the time it was being planned (circa 1995-97). At that time the M&S infrastructure, technology and leadership was not as well established as it is today. The power of the microchip has increased almost three-fold since 1996 and continues to meet or exceed Moore's Law. Examples, in addition to FOTT, that demonstrate the benefits of a SBA approach are shown below.

- The Comanche Simulator/Surrogate Aircraft Fly-Off cost \$20 Million versus \$500 Million for previous similar UH-60 effort.
- Comanche achieved 95% first time fit versus 35% in previous processes and a reduction in labor cost from 19 man-years to one-man month.
- The Tactical Missile Signature center measures missile characteristics for less than \$10K
 per missile versus obtaining the same measurements in a \$700K live fire event.
- The Army's Flexible Computer Integrated Manufacturing program resulted in a 66% reduction in cycle time, \$3M in cost savings and \$3.8M in cost avoidance.
- TARDEC's Low Silhouette Tank Prototype required only 14 engineers/16 months versus
 55 engineers/36 months for a similar effort.
- Army Non-Line of Sight simulators demonstrated a savings of approximately \$12M compared to live-fire and captive-flight testing.
- TECOM's Firing Impulse Simulator saves \$2K per round or \$23K per trunnion bearing test.
- The F22 Program saved \$8 million in fuel tank design and fabrication costs.
- The B2 program estimates saving \$596M to \$894M if M&S was used.
- The Joint Strike Fighter F-15E projects \$5 billion savings in life cycle costs.
- Boeing 777 tooling changes required only 2 versus 40 engineers normally used on older Boeing models.
- INTEL reduced hardware cycle time (design To sample) by 50% while doubling product complexity.²²

Savings are also significant from a training perspective. A tank costs about \$75 per mile versus \$2.50 in a tank simulator. An Apache helicopter costs about \$3100 per hour to fly compared to \$70 in the simulator. Safety, however, doesn't necessarily have to suffer because of less time on the actual equipment. According to National Transportation and Safety Association, simulation has decreased naval aviation accidents from 20 per 100,00 flight hours to 2.39.²⁴ What is important to note is that the savings

shown above cross the life cycle phases and, if applied to all Army programs, would result in significant savings for the Army to plow back into modernization.

The DoD and the Army are pushing forward with new SBA initiatives to enable PMs to take advantage of M&S in their programs. The following section discusses the Army's commitment to SMART by addressing some of the more salient enablers that assist a PM in executing a SMART program.

ARMY COMMITMENT

The Army's commitment to SMART has increased steadily since the early beginnings of the FOTT program. The increased commitment is evident by key Army leaders, the Army's investment in technology and infrastructure, and the slow, but steady cultural change within key Army agencies.

The Army's two top acquisition leaders, Mr. Paul Hoeper, Assistant Secretary of the Army for Acquisition, Logistic and Technology, and LTG Kern, Military Deputy to Mr. Hoeper, are the most outspoken supporters of SMART. Annual conferences such as the SMART conference hosted by LTG Kern lend Army key leaders an opportunity to visibly support the use of M&S. The creation of organizations such as the Army Modeling and Simulation Office (AMSO) and the Army Modeling and Simulation Executive Committee (AMSEC) are another visible demonstration that Army leaders are serious about establishing a strategic direction for Army M&S activities and harnessing the use of M&S across programs. Leading the way for TRADOC, General John N. Abrams sees simulation as a method for reworking doctrine and making the organizational changes being directed by the Army's Chief of Staff, General Shinseki. Army funding of SMART technology, however, is probably the most visible sign of Army efforts to harness and implement M&S.

Information technology has been the engine of change behind the Army's ability to achieve and use a "collaborative" M&S process. It has increasingly become cheaper, more available, and exponentially more powerful in its application and usefulness. It will continue to be a major enabler if for no other reason than the Defense budget will continue to constrain Army modernization and training and force the Army to look to alternatives to make-up the shortfall. However, there are other major reasons why technology will increasingly enable a PM to integrate SMART into his program. One reason is the Army's allocation of funding for SMART related efforts. The FY 00 budget, for instance, shows that at Army level, an estimated \$406M will be spent on M&S across the Research and Development, the Requirements and the Training, Exercise and Military Operations (TEMO) domains. Of these areas, TEMO is expected to spend \$261M to meet M&S needs in that respective domain. For whatever reasons, only \$6M is to be allocated solely toward infrastructure. ²⁶ The \$406M does not include the significant amount that will be spent within individual programs. Affordable 3D accelerators for high-end PCs and workstations are another reason for information technology growth within Industry and DoD. High-end, high fidelity M&S capabilities that use to be cost prohibitive and available only in very specialized machines, is now available in most PCs at a fraction of the cost. ²⁷

The Army's willingness to reach out to Industry for its M&S solutions is yet another reason that technology is increasing the fidelity and realism of Army training simulations. For instance, the Army just recently awarded a \$45M contract to University of Southern California in an attempt to leverage Hollywood's ability to immerse someone in a story and make it believable (like the first 20 minutes of Private Ryan). Teaming with the Entertainment industry will increasingly become the venue for the Army's technology leverage. The final area that will enable M&S technology is the Internet and its connectivity it provides to a growing DoD infrastructure.

The Army's M&S infrastructure has been vastly improved in two key areas – interoperability and creation of a centralized database. Interoperability has been greatly improved through the implementation of the High Language Architecture (HLA), which is now required of all new M&S systems. Older systems have until 1 October 2000 to become HLA compliant or must be retired. ²⁹ The HLA will provide interoperability between services and programs such that PMs will be able to leverage and harness existing M&S tools into programs. Industry should be able to significantly benefit from this HLA approach as well. The HLA should also provide a venue for DoD and the Army to capture the most innovative and state-of-the-art M&S capability resident within small businesses.

The DoD has established the maintenance of a centralized database under the direction on the Defense Modeling and Simulation Office. Each Service in turn has the requirement service to integrate its own peculiar database into an M&S repository. ³⁰ Called the Modeling and Simulation Resource Repository, it is web hosted for easy access, search and download of M&S tools, object code and physical –based entities. The Army 's AMSO provides the Army's link into the DoD Repository. In the end, much redundancy, cost and time should be saved through this valuable capability. However, as the infrastructure continues to expand to meet the Army's M&S SMART vision, the Army's leadership must continue to visibly support SMART to insure it becomes assimilated within the Army's acquisition culture.

While the cultural aspects of implementing SMART are achievable, they are none-the less difficult to overcome within the Army and DoD. There are still those that believe that prototype testing and hardware are the only way to determine system performance. Much of this inertia is created by the simple fact that a significant number of key mid-grade to senior-level Government managers are analog. Until more people that are accustomed to the "digital world" become the senior leaders, cultural change will continue at slow rate. However, the author believes that for the most part, the Army's key leaders have been instrumental in bringing about the necessary cultural change to the point that acceptance of SMART is really no longer the argument. The argument seems to be rapidly shifting to the "how to" aspects of implementing SMART in a given program.

Mr. Hoeper and LTG Paul Kern have their own unique way of describing SMART's ability to deliver better, faster and cheaper systems. Mr. Hoeper's particular emphasis on SMART is translated as the "electronic agility" essential for the Acquisition community to provide the capabilities for the Army After Next.³¹ General Kern likes to refer to SMART "PIT STOP Engineering", or getting inside the Threat's acquisition cycle.³² His message is clear – the Army can't afford to take 12-15 years to develop and field

a system (the pit stop) while the Threat quickly re-modernizes to gain the advantage by buying cheap off-the-shelf and readily available defense technology. He sees SMART as enabling the rapid and economical development, fielding, training, and sustainment of Army XXI and Army After Next (AAN) systems.³³

The Army's key leaders don't see SMART as a means for just acquiring AAN systems. With 70 % of the AAN systems being current systems, SMART can play a major role in re-capitalization of older systems and keeping them viable and sustainable well into the 21st Century. Mr. Hollis, the Deputy Under Secretary for Operational Research and the Army's focal point for M&S, has underscored the ability of existing systems to benefit for M&S without starting from scratch. In those cases, collaboration of existing M&S should be the focus of those systems. 35

Mr. Hoeper, LTG Kern and Mr. Hollis are all members of the Army's Modeling and Simulation Executive Committee (AMSEC). This committee, in conjunction with AMSO, will have to provide the necessary strategic leadership to overcome the challenges of implementing SMART across the Army.

THE CHALLENGING ROAD AHEAD

While great strides have been made since the FOTT program in the implementation of SMART, some significant challenges remain that must be overcome to totally institutionalize SMART within the Army's acquisition process. The major challenges center on funding, technology, and acquisition culture.

One major challenge for the Army to overcome is gaining the necessary funding visibility across its M&S domains. Having this visibility is necessary if the Army is to mitigate duplication of effort and stove-piped environments. As shown earlier, there are significant dollars being thrown at M&S. It's important to spend those dollars wisely so that something other than just virtual systems comes out the pipeline. Although the AMSEC and the AMSO have charted oversight organizations within each of the M&S domains, it seems that these organizations lack the requisite authority to effect change or redirect funding within their respective domain. Lack of authority puts the Domain oversight organizations in merely an advisory position. The true challenge facing the Domain managers is to gain sufficient visibility and control of M&S spending without the stifling the flexibility and innovation within the program offices and research centers. Innovation rarely comes from the top!

Another funding challenge for the Army leadership is that they must be willing to provide sufficient funding up-front to enable PMs to effectively employ M&S early enough in their programs and impact life cycle costs. If statistics hold true, 70% of a system's cost are determined by Milestone I and 85% by Milestone II. The typical "bell-curve" funding stream doesn't provide a SMART leveraged program the ability to that. Fiscal policy must be changed to routinely skew the funding profile in favor of maximizing SMART earlier in a program's life cycle. For instance, by changing the funding stream to allow more dollars to be spent upfront on M&S, the Request for Proposal (RFP) activity can be fully integrated into the SMART approach. The Program Executive Office, Tactical Missiles at Redstone Alabama has begun to look at such an initiative and hopes to begin to apply such an approach with the TOW Fire and Forget

Program.³⁸ The aim is to use Modeling and Simulation as a part of the Source Selection and to leverage that M&S into the entire life cycle of the respective program. The infrastructure to support such an initiative requires more upfront investment than the Army has normally provided in the past.

Changes to the current phases might also be enacted to emphasis Mr. Hoeper's "Electronic Agility". For instance, renaming the *Concept Development Phase* to the *Virtual Concept and Prototype Phase* would help emphasize a SMART approach within the routine way we look at program development. It would also highlight the upfront funding and infrastructure requirements for a SMART acquisition program. The Second phase could then be called the Prototype and Risk Reduction Phase, where the product of the Virtual phase is physically fabricated.

From a technology standpoint, the challenge is buying into the SMART technology and services that best serve the Army's needs. A myriad of government organizations have been created over the past few years at the DoD and Service level that impact upon M&S. Commercial ventures, particularly small ones, continue to materialize in the ever-growing simulation technology market. Nowhere is this more evident than in the training market. For instance, STRICOM spends about a billion dollars a year alone on aviation related training. In other words, buying M&S products and services has become analogous to buying actual weapon systems. Will the myriad of M&S related organizations be able to control the voracious appetite for M&S and apply it where it makes sense? Key players such as AMSO, the Domain managers and the AMSEC must increase their oversight and leadership roles to ensure the Army spends its M&S dollars wisely.

As noted above, leadership is bringing about the cultural change necessary to affect how some in critical positions view SMART and M&S. General Bond from STRICOM, however, finds that there is still quite a "PacMan" mentality about simulation. Furthermore, implementing cultural change within the Army may be exacerbated by the fact that "strategic" leadership normally rotates out prior to being able to fully effect the change. There is some concern that change will not continue when Mr. Hoeper and LTG Kern leave their positions of responsibilities. The author doesn't share that concern. The real issue is whether SMART will experience a "strategic pause." after their departure. The institutionalization of SMART by these two leaders, coupled with the retirement of "analog" managers and the continued austere budget environment should maintain the cultural transformation.

CONCLUSION

Shrinking Defense Budgets and increasing modernization-funding shortfalls will increasingly require Program Managers to leverage M&S as a way to make their programs more affordable. The Department of Defense (DoD) Acquisition policy all but requires M&S to be an integral aspect of a program's acquisition strategy. The DoD name for this initiative is called Simulation Based Acquisition (SBA) and is intended to reduce cost, cycle time and risk while increasing fidelity and utility of systems fielded to the Soldier. The Army's SBA initiative - Simulation and Modeling for Acquisition Requirements and Training, or SMART- seeks to accomplish the goals of SBA by leveraging information technology to

support concurrent and continuous collaboration of the acquisition, requirements and training communities early and throughout a system's life cycle. The Army seeks to leverage this collaborative process as a means to afford the modernization of its forces.

This paper has addressed three salient questions relative to SMART: (1) What does a SMART program look like? (2) What are the benefits to be gained by SMART? (3) What is the Army doing to enable SMART and what are its major challenges? The author has attempted to answer these questions to demonstrate the importance of SMART in enabling Army modernization and re-capitalization efforts in an era of tight fiscal constraint.

The FOTT program was examined as a SMART supported program to enumerate the upfront commitment required by a program office, the importance of leveraging existing M&S, the application of M&S across acquisition phases and programs and the potential for significant reductions in testing, hardware-cost and time. The FOTT program also provided a very good example of how M&S can be leveraged across the acquisition, requirement, and training aspects of a program. Examples of other Service and Industry SBA supported programs were shown to highlight the potential level of savings to be gained by applying SMART across all Army programs.

Army commitments and potential challenges were discussed to show that the Army's leadership is focused on making SMART a routine acquisition approach. Funding commitments, Army-level M&S committees and the ever-growing M&S infrastructure show that SMART is here to stay. The Army's leadership recognizes that SMART can significantly contribute to Army modernization through reductions in the development cycle time and total life cycle costs of its emerging and legacy systems.

Regardless of the significant progress that has been made in institutionalizing SMART, significant skepticism remains that could stall the SMART revolution. Many in the Army culture still see SMART as being only second best to real hardware. Obtaining M&S technology that will best serve the Army's needs, coupled with changing how programs are funded, are challenges that will require immediate attention of the Army's leadership. Otherwise, SMART will not be brought online in sufficient time to effectively support Army modernization. Fortunately, key Army leaders such as Mr. Hoeper, LTG Kern and LTG Abrams are the most visible and ardent supporters of SMART. They continuously share their vision of SMART delivering affordable systems in less time and with more utility. Their strategic vision and leadership in key Army M&S organizations will help ensure that SBA will remain a SMART approach to Army modernization long after their departure.

Word Count: 7487

ENDNOTES

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- ²LTG Paul J. Kern and Ellen M. Purdy, "Simulation Based Acquisition is SMART for the Army", <u>Army RD&A</u>, (May-June 1999): 5.
 - ³ Ibid.
 - ⁴ Ibid.
- ⁵ Michael V.R. Johnson, Mark E. McKeon and Terrance R. Szanto, <u>Simulation Based Acquisition: A New Approach</u>, Report Of the DSMC 1997-1998 Military Research Fellows (Fort Belvoir, VA: Defense Systems Management College, Dec 1998), 1-1.
 - ⁶Ibid A14"
- ⁷Department of Defense, Department of Defense Modeling and Simulation Master Plan, DoD Directive 5000.59, Washington D.C., December 1997, Glossary.
- ⁸Albert B. Garcia, Robert P. Gocke, Jr. and Nelson P. Johnson, <u>Virtual Prototyping: Concept to Production</u>, Report of DSMC 1992-1993 Military Research Fellows (Fort Belvoir, VA, Defense Systems Managenment College), 153.
 - ⁹ Dr. Patricia Sanders, "SBA: the Revolution Is Coming," <u>Army RD&A</u>, (May-June 1999): 8.
- ¹⁰ Simulation Support Plans, http://www.msosa.dmso.mil/sba/documents.asp>, Internet, Accessed 10 February 2000.
- ¹¹ <u>Simulation Support Plan for Follow-On To TOW</u> (Close Combat Anti-Armor Weapon Systems Project Office, Huntsville, AL, January 1998), 8.
- ¹² Follow-ON TO TOW Acquisition Strategy (Close Combat Anti-Armor Weapon Systems Project Office, Huntsville, AL, October 97), 8.
- ¹³ Follow-On-To-TOW Briefing, "Simulation Based Acquisition", Close Combat Anti-armor Project Office, January 1998.
- ¹⁴ CASTFOREM is the acronym for Combined Arms and Support Task Force Evaluation Model, which is used for large force-on-force analysis (battalion corps). JANUS is a similar program that is used for small force-on-force analysis (section company)
- ¹⁵ In requirement's lexicon, KPPs represent the most critical performance requirements of a system, which if not met during development, can cause the program to be terminated or restructured.
- ¹⁶ ATACMS-BAT-Army Tactical Missile Systems, JAVELIN, NLOS- Non-Line-of-Sight and LOSAT-Line-of-Sight-Antitank are weapon system programs managed within the Program Executive Office for Tactical Missile Systems, Huntsville, AL.

- ¹⁷ Close Combat Anti-Armor Weapon Systems Project Office Briefing, "SMART Acquisition", January 1999.
 - ¹⁸ Simulation Support Plan for FOTT, 43.
 - ¹⁹ FOTT Program, Close Combat Anti-armor Project Office, Huntsville, AL.
- ²⁰.Roger L. Carter, "SMART Acquisition" Briefing, Close Combat Anti-armor Weapons Systems Project Office, Huntsville Al, June 1999.
- Moore's Law states that computing power will double every 18 months but costs will remain constant. The PC market bears this out.
- ²² Program Executive Office for Tactical Missiles, "SMART –The Cornerstone of Total Life Cycle Management," Huntsville, AL, April 1999.
 - ²³ Harold Kennedy, "Simulation Reshaping Military Training", <u>National Defense</u>, November 1999, 27.
 - ²⁴ Ibid.
 - ²⁵ Sadra I. Erwin, "Nintendo Generation Blazes Training Trails", <u>National Defense</u>, January 2000, 4.
- ²⁶ Dr. Hank Dubin, "RDA Investment Strategy Update", Briefing to the Army Modeling and Simulation Executive Committee", November 1999.
- ²⁷ Simulation Training and Instrumentation Command, PC-Based Technology Invades Army Simulation,http://www.stricom.army.mil/PRODUCTS/PC_BASED_TECH/home.html, accessed 10 December 1999.
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 - ³¹ Mr. Paul J. Hoeper, "The Advantages of SMART", <u>Army RD&A</u> (May-June 1999), Inside Cover.
 - ³² Paul J. Kern, "Pit Stop Engineering: SMART Simulation Based Acquisition," 8 December 1998.
 - 33 Ibid.
 - ³⁴ Kern and Purdy, <u>RD&A</u>, 7.
- ³⁵ Walt W. Hollis, "Simulation Based Acquisition: Can We Stay the Course," <u>Army RD&A</u>, May-June 1999, 13.
 - ³⁶ Dubin, AMSEC Briefing.

³⁷ 1997-1998 Military Report of the DSMC Military Fellows, 1-3.

³⁸ Program Executive Office for Tactical Missiles Briefing, "Smart, The Cornerstone Of Total Life Cycle Management".

³⁹ Linda Billings, "Vendors Strive for Smaller, Faster Cheaper Simulators", <u>National Defense</u>, November 1999, 38.

 $^{^{40}}$ Erwin, "Nintendo Generation Blazes Training Trails," 4.

⁴¹ Sandra L. Erwin, "Technology Procurement Chief Revamps Weapon Testing Shop", <u>National Defense</u>, November 1999, 36.

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